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#53

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I. Introduction

North of Chesapeake Bay, one of the foremost problems of oyster planters is to obtain a regular supply of seed oysters; to the south, the problem becomes one of how to handle an overly abundant set. Virginia is the most northerly state with an adequate supply of seed oysters, and setting should not be a problem. The natural set will suffice if proper steps are taken to catch and utilize it. We are most fortunate in Virginia in having a consistent set of moderate intensity resulting in high quality seed oysters. At present only the best seed oysters, those from the James River, are being used; a large portion of these are wasted, almost deliberately, by sacrificing them to predators.

The public oyster grounds include most of the natural oyster beds. Being hard shelly bottoms with a natural set, many of these are being put to their best use as seed-oyster grounds. Private grounds, often lacking in natural set, or with the set destroyed by predation, are usually suitable for growth-and-fattening only. While the logical procedure is to move oysters from public seed grounds to private growing grounds, in practice only the James River is used as a seed area. Tributaries, such as the Corrotoman and Piankatank Rivers, which would make good seed areas, despite poor growth are used as growing and fattening grounds. Other public grounds, such as the Rappahannock River, have rather poor setting and oysters are sparse.

The first studies of oyster setting in Virginia waters were made by Loosanoff in 1931. From 1940 to 1945, Menzel, Hopkins, and Mackin collected some records. In the past eight years fairly intensive records of setting and survival have been collected from the three major tributaries in Virginia, the James, York, and Rappahannock Rivers.

II. Setting

a. Seasonal Patterns of Setting

In Virginia setting usually begins the first week of July and continues until about the beginning of October--a period of 90 to 100 days (Andrews 1951). Setting is continuous in the James, and nearly so in the York, but in the Rappahannock it may stop for several weeks during the season. Two periods of heavier setting can usually be distinguished, the first in mid-July and the peak of the second from the

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middle of August to the middle of September. In each of these periods, covering three or four weeks, setting gradually builds to a peak and falls almost as slowly.

In the James the early set is unimportant--amounting to less than 10 per cent of the total set. The late set usually reaches a peak about the first of September. In the York River, early and late sets may be of equal magnitude although often the late is more intensive. In the Rappahannock River, the early set, although small as compared with the other rivers, is the most consistent and important. Only rarely does a late set of any consequence occur. The first good set in the upper Rappahannock in ten years, in 1954, was late in the season. Further up the Bay in Maryland waters, the pattern for the Rappahannock River seems to apply, with early sets of low magnitude predominating but occasional late sets of good intensity.

An interesting feature of setting in the Virginia rivers is the uniformity in a particular season of the time pattern throughout each river. As many as ten stations have been followed for setting pattern in the James River. Usually, the peaks and lows of setting occur in the same week for all stations in a river. While in a particular week the actual amount of set varies greatly from one station to another, the relative intensity of the set from week to week is similar for all stations. This pattern of timing and intensity of set suggests that the same broods of larvae are providing spatfall for the whole river.

b. Intensity of Setting

The methods of estimating the amount of set or strike vary with the purposes for which the data are to be used. For the commercial oysterman, a count of spat on natural culch in late fall or early spring suffices. For the scientist seeking causes and explanations, it is desirable to know the initial set as well as the surviving set at later times. Too often no distinction is made between initial set and surviving set. We have found that the number and size of spat on collectors at the end of two weeks exposure are often similar to that found at the end of one week. It is evident that in these samples most of the spat setting the first week had died by the end of the second.

Three different records of the quantity of set have been taken in Virginia. First, weekly exposure of collectors is assumed to approximate initial set. For this count 10 to 40 marked shells are mixed in a wire bag with about a quarter of a bushel of filler shells. Second, survival or seasonal records are obtained by exposing shells of uniform size and quality in wire bags throughout the setting season. All the spat on a quarter of a bushel of shells are counted. Third, the surviving set on natural culch is obtained each fall from samples dredged from public grounds. All the spat on samples from one-quarter to one bushel in size are counted. Samples of each of these three kinds of records, from the best seed ground in the James River, are shown in Table I.

Table I. Samples of Records of Setting on Wreck Shoal

James River, Virginia

(Number of spat per shell)

Year	Total of weekly sets for season	Set in seasonal shell bags	Set on natural culch
1947	313	13	3.6
1948	308	9	3.5
1949	215	15	7.4
1951	80	8	6.4
1952	80	6	3.8

In the James River, total weekly sets for a season may exceed 300 spat per shell. For weekly setting records, clean culch is exposed each week, so that this figure represents a setting rate or potential set under nearly optimal conditions. During peak setting weeks, sets of 60 to 75 spat are obtained on individual shells. Seasonal sets on individual shells in wire bags seldom exceed 15 spat per shall. The average seasonal catch for natural culch is usually less than five spat per shell. The commercial set is reduced to a small percentage, usually less than five per cent, of the initial set.

In the York and Rappahannock Rivers, initial set is considerably lower, survival somewhat better except where drills are active, and the commercial set lower than in the James. An average of one spat per shell is seldom exceeded on natural culch. Some of the smaller tributaries obtain a better set but as yet none studied exceed the James in amount or consistency of setting.

In the absence of drills, it appears that the survival rate increases as the strike decreases, although nowhere in Chesapeake Bay is setting so heavy that serious crowding is encountered. Survival increases on up-river grounds where salinities are low. At Deep Water Shoals in the James, the set is quite low, and dependent upon salinity conditions, but survival as high as 80 per cent has been recorded. It appears that late-setting spat survive better than early set, despite overwintering at a smaller size--often 1 to 3 millimeters.

Wherever oyster drills are present, the survival picture is violently upset. In the James River only Brown Shoals, the lowest of the seed beds, is infested. Scarcely any of the moderate set on Hampton Bar survives. Drills are present in the lower parts of the York and Rappahannock Rivers. In the York, where the set is moderate, scarcely any survive beyond an age of three or four weeks. In the Rappahannock lower salinities hamper the activities of drills and losses are often minimal.

c. Gradients of Setting

While local variations from a variety of causes are expected, it appears that in Virginia setting is heaviest near the mouths of rivers and decreases progressively upriver (Table II). If counts are not made soon after setting, a great many factors, such as predators

Table II. Vertical and Horizontal Setting Gradients,

James River, 1952

Shore	Bar	Miles above mouth of river	Total of weekly sets for season	Number of spat per shell: Surviving set on seasonal shell bags	Number of spat per shell: Set on natural cultch
L	Brown Shoal	0	90	5.6	2.92
R	Dog Shoal	0	78	bags lost	1.24
	White Shoal	3	42	3.3	
L	Wreck Shoal	6	40	5.8	3.00
R	Days Point	6	11	3.8	0.51
L	Deep Water Shoal	13	4	0.4	0.26
R	Point of Shoal	10	3	2.6	0.67

and silting, tend to mask this gradient. There is also a heavier set on the left side of the channel (facing downriver) than on the right side, probably related to the greater inflow of salt water on the left side. Most of the natural oyster beds are located on the left sides of the rivers.

III. Brood Stock

One of the factors often cited for failure of setting is lack of a sufficient stock of spawning oysters. In Virginia waters no one has seriously attempted to estimate the quantity of brood stock for a body of water. Wild populations of adult oysters abound everywhere, so that records of planted oysters do not include all the potential spawners. The importance of brood stock looms large in the minds of oystermen and the public. The methods suggested for utilizing brood oysters often include placing the biggest and oldest oysters obtainable in the most inaccessible places, such as the heads of creeks and rivers. This is probably based on observations that setting is often good in the relatively enclosed waters of creeks. The source of the spawn for these sets remains unknown.

In 1952 the Virginia assembly responded to this popular interest by providing a sanctuary for spawning oysters in the James River. The sanctuary, not to exceed 1,000 acres, has not yet been established, but the question arises as to how such areas would be selected. The law provides that any area in the James River may be closed or opened to tonging according to the need. How would such areas be managed to insure thriving populations of spawning oysters? Would young or old oysters make the best brood stock? Would an area of this size be effective if thousands of acres of wild oysters were depleted?

My own opinion is that the importance of brood stock has been over-rated, at least in southern waters. The process of oyster reproduction is obviously a wasteful one. The amount of spawn may be far less important than physical conditions and the food supply for larvae. A comparison of the James and Rappahannock Rivers in Virginia illustrates this point. The James River always has a good set; a large population of wild oysters, mostly under two years of age, furnishes spawn. These oysters, in addition to being small, are always poor and produce very thin layers of gonadal material. Planted oysters are scarce in the James. In contrast, spawn in the Rappahannock River comes from a large population of planted oysters up to five years of age. These oysters are typically fat and produce thick layers of spawn. The best oysters and a large part of the planted grounds are found in the upper Rappahannock River between Towles Point and Sharps, where setting is extremely poor. Wild oysters are also large and of good quality but not abundant. In 1954, without any known change in the stock of oysters, a good set occurred in the upper Rappahannock River for the first time in ten years.

While the number of oysters is very large in the James, individual Rappahannock oysters greatly excell in the quantity of spawn produced. The brood stock in the Rappahannock would seem optimal, but setting regularly fails, whereas in the James River apparently inferior brood stock always produces a set.

In attempting to provide large stocks of brood oysters, oystermen may have failed to consider the spawning habits of their oysters. It is obvious that spawning patterns are quite different in the waters of Virginia and Long Island Sound. In northern waters spawning is concentrated in a few mass discharges. In Virginia some spawning must occur every few days for a period of three months. What pattern of spawning prevails in Virginia to provide setting larvae for twelve consecutive weeks of setting? The gradual build-up and decline in a period of heavy setting may consume as much as five weeks time. Unless larvae live much longer than the 10 to 14 days we assume at temperatures of 27 to 30° C., individual oysters must have many spawnings. Unlike oysters in northern climes, waiting patiently for water temperatures to reach a certain minimum level, oysters in warm waters may be able to conserve their spawn and release it gradually, thereby utilizing a long warm season. Is it not probable, that in their spawning habits oysters have become adapted to the climatological conditions of their native waters? Native oysters have usually excelled oysters from other waters in growth. The difficulty experienced by Loosanoff (personal communication) in getting Virginia oysters to spawn by artificial methods suggests that physiological differences exist. These differences may include distinct spawning patterns.

IV. Distribution of Larvae

The pattern of spatfall may be presumed to represent the final distribution of mature larvae during the last tidal cycle of their free-swimming life. The similarity of setting patterns implies that the same swarms are carried over each bar but that the oyster larvae are more abundant in the lower part of the swarm. Since in our river estuaries new water is being added at both ends, the larvae must select a favorable stratum for transport upstream, or be continually lost from the system at the lower end and become progressively less abundant upriver (Pritchard 1951). Pritchard noted that in the James larvae were more concentrated than would be expected from a consideration of the mixing processes.

I believe that in studies of the distribution of oyster larvae, too much credit has been given to the activities of the larvae and too little to the physical system of currents, tides, wind, and turbulence. Perhaps the studies of the Chesapeake Bay Institute are a step in the right direction. I am inclined to believe that larvae are distributed passively, with their own active motion essentially limited to vertical migrations. The roiled water on the bottom of the James River, sometimes two feet deep, would seem to be a most inhospitable place for larvae to rest when the tide is running. The gradient of setting which appears to exist in Virginia rivers is indirect evidence of passive distribution. In addition to the local variations mentioned, there are also "pockets"--turns in the river--which tend to trap larvae. Each of the three rivers studied has one of these "pockets," which frequently have the highest sets in their respective rivers. There are such "pockets" in the James River at Jail Point, in the York at Gloucester Point, and in the Rappahannock at Towles Point.

In 1950, in cooperation with the Chesapeake Bay Institute of The John Hopkins University, an intensive survey of oyster larvae in the James River was made. The time was chosen to coincide with the heavy set which occurred about the first of September. One-hundred liter samples were taken every two hours and sometimes every hour for a continuous period of three days. At Wreck Shoal, where sets were averaging 40 spat per shellface per week (80 per shell), late umbo and eyed larvae were found infrequently; many samples both from bottom and surface waters had no larvae of any size. Samples of 500 liters did not improve the catch of larvae. It would have been quite possible to have taken daily plankton samples and found no larvae. Apparently larvae were not evenly distributed throughout the waters of the river, although a characteristic of setting in the James is the similarity of timing and relative intensity of setting for all bars. Some evidence was adduced that in successive tidal cycles the same larval swarms passed over beds several times (Pritchard 1953). Pritchard calculated that only one late stage larva per 100 liters of water is needed to produce the sets observed in the James. A comparison with published accounts of larval studies leads to the conclusion that larvae are relatively scarce in the James River. Yet, setting is adequate and consistent from year to year. Probably the explanation lies in the long setting season, which allows numerous relatively small broods to be released, thus increasing the chances of circumventing the various factors of attrition.

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